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ordinary plate, the size of a cent, fastened to its centre, could be used either as a receiving or sending disc over a short line; but it did not articulate very well; this defect, however, may have been caused by the want of homogeneity in the mica. The results of my experiments show that we can remove nearly one third of the iron plate (the whole plate being two inches and a half in diameter) without seriously injuring the articulation; and, furthermore, that a piece of iron three quarters of an inch in diameter is sufficient to cause a plate of mica two inches and a half in diameter to articulate partially and sufficiently to be heard over a short line.

No. XIX. — ON A STANDARD FOR ESTIMATING THE AMOUNT OF LIGHT REFLECTED BY VARIOUS SUBSTANCES.

By A. H. Lee.

Presented Dec. 10, 1879.

The following experiments were undertaken with the view of obtaining a standard reflecting surface, with which the light reflected from various reflecting surfaces could be compared. I have collected various experiments with white paper, tinted paper, and silvered surfaces.

At first I used the photometer due to Professor Pickering, and described in his work on *Physical Manipulations*, Vol. I. p. 132. L is a candle; α and β are two mirrors, which reflect the light of the candle to the Bunsen disc A, which slides between the mirrors α and β.

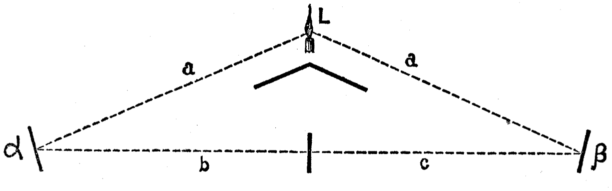

Fig. 1.

If I represents the reflection from mirror α, and I' that from β, we have at A

$$\frac{I}{(a+b)^2} = \frac{I'}{(a+c)^2}; \quad \text{or} \quad I = \frac{(a+b)^2}{(a+c)^2} I'.$$

Percentage of Light reflected from Different Substances.

Experiments with one candle comparing the reflective power of paper and a mirror. (Fig. 1.) Paper was foolscap.

Obs.	Dist. *a* + *b*.	Dist. *c*.	Ratios.
1	73	64	$\frac{5329}{14641} = \frac{1}{2.75}$
2	76	61	$\frac{5776}{13904} = \frac{1}{2.41}$
3	75	62	$\frac{5625}{14241} = \frac{1}{2.53}$
4	75	62	" $= \frac{1}{2.53}$
5	74	63	$\frac{5476}{14400} = \frac{1}{2.63}$
6	77	60	$\frac{5929}{13689} = \frac{1}{2.29}$
7	76	61	$\frac{5776}{13924} = \frac{1}{2.41}$
8	76	61	" $= \frac{1}{2.41}$
9	76	61	" $= \frac{1}{2.41}$
10	76	61	" $= \frac{1}{2.41}$

Percentage in terms of reflection of mirror 40458

Percentage of Total Light reflected from a Mirror.

Experiments with two candles. (Fig. 2.) In the following experiments a candle was substituted for the mirror at α, in order to get the percentage of total light reflected, eliminating the coefficient of reflection of a mirror. To eliminate the error which might arise from unequal combustion, the candles were changed about during each observation, and the average of the two ratios taken. The following are the results: —

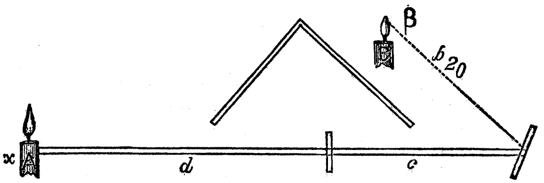

Fig. 2.

Candle.	Position.	Dist. *d*.	Dist. *b* + *c*.	Ratios.	Averages.
A	α	56	44	$\frac{1}{1.62}$	$\frac{1}{1.76}$ (1)
B	α	58	42	$\frac{1}{1.90}$	
A	α	56	44	$\frac{1}{1.62}$	$\frac{1}{1.84}$ (2)
B	α	59	41	$\frac{1}{2.07}$	

Candle.	Position.	Dist. d.	Dist. $b + c$.	Ratios.	Averages.
A	α	57	43	$\frac{1}{1.75}$	$\frac{1}{1.49}$ (3)
B	α	53	47	$\frac{1}{1.23}$	
A	α	58	42	$\frac{1}{1.90}$	$\frac{1}{1.76}$ (4)
B	α	56	44	$\frac{1}{1.62}$	
A	α	56	44	$\frac{1}{1.62}$	$\frac{1}{1.55}$ (5)
B	α	55	45	$\frac{1}{1.49}$	
A	α	58	42	$\frac{1}{1.90}$	$\frac{1}{1.83}$ (6)
B	α	57	43	$\frac{1}{1.75}$	

Percentage (average of six observations) 586

FOOLSCAP.

Candle.	Position.	Dist. d.	Dist. $b + e$.	Ratios.	Averages.
A	α	67	33	$\frac{1}{4.1}$	$\frac{1}{4.1}$ (1)
B	α	67	33	$\frac{1}{4.1}$	
A	α	66	34	$\frac{1}{3.76}$	$\frac{1}{4.35}$ (2)
B	α	69	31	$\frac{1}{4.95}$	
A	α	68	32	$\frac{1}{4.51}$	$\frac{1}{4.13}$ (3)
B	α	66	34	$\frac{1}{3.76}$	
A	α	67	33	$\frac{1}{4.1}$	$\frac{1}{4.1}$ (4)
B	α	67	33	$\frac{1}{4.1}$	
A	α	67	33	$\frac{1}{4.1}$	$\frac{1}{4.30}$ (5)
B	α	68	32	$\frac{1}{4.51}$	
A	α	67	33	$\frac{1}{4.1}$	$\frac{1}{3.93}$ (6)
B	α	66	34	$\frac{1}{3.76}$	

Percentage (average of six observations) 2309

" of light reflected from paper compared with mirror 405

Percentage of total light reflected from mirror . . .586

" of total light reflected from paper. . . .2373

" " " " " by direct experiment 2309

Difference 0064

The above result is rather a remarkable confirmation of the correctness of the theory of this method of measuring reflection.

Percentage of Total Light reflected from Colored Papers.

GREEN.

Candle.	Position.	Dist. *d.*	Dist. $b + c$.	Ratios.	Averages.
A	α	70	30	$\frac{1}{5.444}$	$\frac{1}{5.444}$ (1)
B	α	70	30	$\frac{1}{5.444}$	
A	α	70	30	$\frac{1}{5.444}$	$\frac{1}{5.195}$ (2)
B	α	69	31	$\frac{1}{4.95}$	
A	α	68	32	$\frac{1}{4.51}$	$\frac{1}{5.25}$ (3)
B	α	71	29	$\frac{1}{5.99}$	
A	α	71	29	$\frac{1}{5.99}$	$\frac{1}{5.47}$ (4)
B	α	69	31	$\frac{1}{4.95}$	
A	α	71	29	$\frac{1}{5.99}$	$\frac{1}{5.99}$ (5)
B	α	71	29	$\frac{1}{5.99}$	
A	α	70	30	$\frac{1}{5.44}$	$\frac{1}{5.71}$ (6)
B	α	71	29	$\frac{1}{5.99}$	
Percentage					.18

NOTES. — The spot is colored green on one side by reflection from the paper. The intensity of the color increases with the decrease of the distance from the paper. The other side of the spot is colored pink, which also varies with the distance from the paper, becoming white as the distance increases, and more distinctly pink as the distance decreases. The spot alone is colored. The coloring matter of this paper was found to be arsenic.

RED PAPER.

Candle.	Position.	Dist. *d.*	Dist. $b + c$	Ratios.	Averages.
A	α	74	26	$\frac{1}{8.10}$	$\frac{1}{7.70}$ (1)
B	α	73	27	$\frac{1}{7.31}$	
A	α	72	28	$\frac{1}{6.53}$	$\frac{1}{6.92}$ (2)
B	α	73	27	$\frac{1}{7.31}$	
A	α	73	27	$\frac{1}{7.31}$	$\frac{1}{6.92}$ (3)
B	α	72	28	$\frac{1}{6.53}$	
A	α	73	27	$\frac{1}{7.31}$	$\frac{1}{7.31}$ (4)
B	α	73	27	$\frac{1}{7.31}$	
A	α	73	27	$\frac{1}{7.31}$	$\frac{1}{7.12}$ (5)
B	α	72	28	$\frac{1}{6.92}$	
A	α	71	29	$\frac{1}{6.00}$	$\frac{1}{6.26}$ (6)
B	α	72	28	$\frac{1}{6.53}$	
Percentage					.1406

NOTES. — In the case of red paper the whole of the screen is slightly colored red, but the spot is principally colored. The other side is colored pale green, which deepens as the red grows stronger.

YELLOW PAPER.

Candle.	Position.	Dist. *d*.	Dist. $b + c$.	Ratios.	Averages.
A	α	69	31	$\frac{1}{4.95}$	$\frac{1}{5.19}$ (1)
B	α	70	30	$\frac{1}{5.44}$	
A	α	69	31	$\frac{1}{4.95}$	$\frac{1}{5.19}$ (2)
B	α	70	31	$\frac{1}{5.44}$	
A	α	69	31	$\frac{1}{4.95}$	$\frac{1}{4.53}$ (3)
B	α	67	33	$\frac{1}{4.10}$	
A	α	69	31	$\frac{1}{4.95}$	$\frac{1}{4.73}$ (4)
B	α	68	32	$\frac{1}{4.51}$	
A	α	70	30	$\frac{1}{5.44}$	$\frac{1}{4.60}$ (5)
B	α	66	34	$\frac{1}{3.76}$	
A	α	69	31	$\frac{1}{4.95}$	$\frac{1}{4.73}$ (6)
B	α	68	32	$\frac{1}{4.57}$	
Percentage					.2070

NOTES. — The spot is colored yellow on one side, and pearl on the other. The contrast decreases as the distance from the paper increases.

The general results are as follows: —

White	.2409
Yellow	.2070
Green	.1810
Red	.1551

SILVERED MIRROR (FACE).

Candle.	Position.	Dist. *d*.	Dist. $b + c$.	Ratios.	Averages.
A	α	51	49	$\frac{1}{1.083}$	$\frac{1}{1.286}$ (1)
B	α	55	45	$\frac{1}{1.49}$	
A	α	52	48	$\frac{1}{1.16}$	$\frac{1}{1.08}$ (2)
B	α	50	50	$\frac{1}{1.00}$	
A	α	55	45	$\frac{1}{1.49}$	$\frac{1}{1.43}$ (3)
B	α	54	46	$\frac{1}{1.37}$	

Candle.	Position.	Dist. *d*.	Dist. $b + c$.	Ratios.	Averages.
A	α	52	48	$\frac{1}{1.16}$	$\frac{1}{1.19}$ (4)
B	α	53	47	$\frac{1}{1.22}$	
A	α	51	49	$\frac{1}{1.08}$	$\frac{1}{1.22}$ (5)
B	α	54	46	$\frac{1}{1.37}$	
A	α	54	46	$\frac{1}{1.37}$	$\frac{1}{1.30}$ (6)
B	α	53	47	$\frac{1}{1.22}$	

Percentage 80

Notes. — The silvered surface of the mirror reflects the yellow color of the candle, while the mercury amalgam mirror gives a more grayish color. Hence, the convenient method of viewing the spot on both sides at once by a mirror, is no longer accurate.

SILVERED MIRROR (GLASS SURFACE).

Candle.	Position.	Dist. *d*.	Dist. $b + c$.	Ratios.	Averages.
A	α	54	46	$\frac{1}{1.37}$	$\frac{1}{1.37}$ (1)
B	α	54	46	$\frac{1}{1.37}$	
A	α	52	48	$\frac{1}{1.16}$	$\frac{1}{1.26}$ (2)
B	α	54	46	$\frac{1}{1.37}$	
A	α	53	47	$\frac{1}{1.22}$	$\frac{1}{1.22}$ (3)
B	α	53	47	$\frac{1}{1.22}$	
A	α	52	48	$\frac{1}{1.16}$	$\frac{1}{1.33}$ (4)
B	α	55	45	$\frac{1}{1.49}$	
A	α	57	43	$\frac{1}{1.75}$	$\frac{1}{1.42}$ (5)
B	α	51	49	$\frac{1}{1.08}$	
A	α	54	66	$\frac{1}{1.37}$	$\frac{1}{1.18}$ (6)
B	α	50	50	$\frac{1}{1.00}$	

Percentage 775

Notes. — The back surface of the silvered mirror gives successive reflections.

General Result. — The face of the silvered mirror has been found to reflect more light than any of the six surfaces tried above, and it would probably be found to reflect more than any other surface on account of the superior whiteness of the metal. The double transmission through the glass costs the difference between 80 and 77.5, or 2.5 per cent, disregarding the amount reflected from the surface of the glass. The silvered mirror used was not perfect, and a perfect silver surface would undoubtedly reflect more, — probably as much as 91 or 92 per cent. Since relative results were desired, but one reflecting angle was used in the above experiments.

No. XX. — EFFECT OF DISTANCE ON APPRECIATION OF COLOR.

By W. H. Schwartz.

Presented Dec. 10, 1879.

Herbert Spencer, in his *First Principles of Philosophy*, adduces the following as an instance of heterogeneity in the formation of the Universe: —

"While the yellow stars are found in all parts of the heavens, the red and blue stars are not so; there are wide regions in which both red and blue stars are rare; there are regions in which the red are comparatively abundant."

Professor Trowbridge suggested to me that the relative distance of the stars, and their relative size, might affect our perception of color, and that a colored star might appear of a faint white or yellow tint on a dark background, if it were distant, compared with a colored star which was at a less distance: in other words, that Herbert Spencer's instance could not be adduced as an evidence of heterogeneity.

I therefore undertook the following investigation.

The solar spectrum having been projected upon a white wall, I covered it by a white screen provided with vertical slits at various distances, and in this way compared my appreciation of the color seen through these slits at various distances. I speedily found that the following experiments with slips of colored paper represented the results which I obtained with the normal colors of the spectrum, and brought out the facts equally well. I therefore abandoned the spectrum, and confined myself to the colored papers.

Red, Green, and Yellow.

I first tried strips of red, green, and yellow on a *white background.* The strips were about .0015 meter wide and .025 meter long. They were parallel and about .01 meter apart.